

**FINAL REPORT**  
**PERFORMANCE REPORT**  
**SURVEYS AND INVESTIGATIONS PROJECTS**  
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**MISSOURI**  
**FEDERAL AID PROJECT NO. W-13-R-55 (2001)**

**STUDY NO. 18:** Wetland Ecology Studies in the Missouri River Floodplain

**Job No. 2:** Herpetofaunal communities of Missouri River floodplain wetlands: dynamics of prey for riverine birds and mammals

By

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## FINAL REPORT

### SURVEYS AND INVESTIGATIONS PROJECTS

#### STATE OF MISSOURI

**PROJECT NO. W-13-R-55 (2001)**

**Study No. 18**

**Job No. 2**

**Reporting Period:** July 1, 2001 through June 30, 2002

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#### ABSTRACT

During the previous century, about 41,000 ha of aquatic habitat was lost in the lower Missouri River alluvial valley. The Great Flood of 1993 reversed that trend by creating 466 new wetlands in the alluvial valley between Kansas City and St. Louis, Missouri. We examined amphibian and turtle use of these new flood-created wetlands and of pre-flood existing wetlands during 1996 through 1998 to determine the value of the new and existing wetlands to amphibians and turtles. Specifically, we examined the species composition and relative abundance of amphibian and turtle communities at four existing (farmed temporary, unfarmed temporary, wooded slough, and remnant) and two flood-created (non-connected scour and connected scour) wetland types. In addition, we determined what habitat features predict amphibian and turtle relative abundance at the wetlands. Amphibian communities were sampled using drift fences and funnel traps next to and within wetlands. Turtle communities were sampled using baited and unbaited hoop traps within wetlands. Turtle movements in and adjacent to floodplain wetlands were also described. Selected

turtle species were marked with radio transmitters to follow their movements within and adjacent to alluvial valley wetlands.

The following amphibian species were captured around wetlands: small-mouthed salamander (Ambystoma texanum), eastern tiger salamander (Ambystoma tigrinum tigrinum), Blanchard's cricket frog (Acris crepitans blanchardi), eastern American toad (Bufo americanus americanus), Great Plains toad (Bufo cognatus), Woodhouse's toad (Bufo woodhousii woodhousii), gray treefrogs (Hyla chrysoscelis - Hyla versicolor Complex), northern spring peeper (Pseudacris crucifer crucifer), western chorus frog (Pseudacris triseriata triseriata), plains leopard frog (Rana blairi), bullfrog (Rana catesbeiana), southern leopard frog (Rana sphenoccephala), and plains spadefoot (Spea bombifrons).

The amphibian species composition was similar at farmed temporary, unfarmed temporary, wooded slough, remnant, and non-connected scour wetlands (nine to twelve species). Connected scour wetlands had the fewest number (seven) of amphibian species. Amphibian relative abundance was greatest and similar around farmed and unfarmed temporary, wooded slough, and non-connected scour wetlands. Larval amphibian abundance was greatest in farmed temporary wetlands in 1997, and tended to be greater in farmed temporary wetlands in 1996 and 1998. Few amphibian larvae were captured at flood-created wetlands. Amphibian abundance could be predicted by wetland type, prevalence of fish or wetland hydroperiod, and distance of the wetland to the river.

The following turtle species were captured at wetlands: common snapping turtle (Chelydra serpentina serpentina), western painted turtle (Chrysemys picta bellii), false map turtle (Gratemys pseudogeographica pseudogeographica), red-eared slider (Trachemys scripta elegans), midland smooth softshell (Apalone mutica mutica), eastern spiny softshell (Apalone spinifera spinifera). Aquatic turtles were captured in every wetland type, but turtle species richness was greatest in wooded sloughs, remnant, and flood-created wetlands. Few turtles were captured in and species

richness was least in temporary wetlands. Turtle species associated with lentic habitats were most likely found in remnant wetlands. Turtles associated with lotic habitats were most likely found in connected scour wetlands. Lentic turtle species were associated with wetlands that were frequently flooded, relatively distant from the river, and insect rich. Lotic turtle species were most closely associated with wetlands that were turbid, close to the river, and relatively insect poor. Radiomarked false map turtles and red-eared sliders primarily used the river and a non-connected scour wetland, and used farmed temporary wetlands and forest cover < 4 years old the least. Radiomarked turtles solely used the river or a non-connected scour wetland during September through February. During March through August, turtles used all habitats nearly equally. Turtles captured and marked on a widespread trapping effort displayed few differences in wetland use among false map turtles and red-eared sliders. False map turtles were captured most in wooded sloughs and least in temporary wetlands. Red-eared sliders were captured most in wooded sloughs and least in the Missouri River. There were greater differences between sexes than species. Females moved more and further from the river than males. Juvenile turtles were more likely to be captured further from the river and moved less than adults.

Flood-created wetlands are not likely to be sites of many amphibian breeding efforts because they contain fish, are more permanent lake-like waterbodies, or are occasionally connected to the river and thus reinvaded by fish. We think river management which reconnects the river to the alluvial valley and resembles historical flows is not in conflict with amphibian breeding efforts in the Missouri River alluvial valley because of the timing and pattern of historical flows. We also suggest Wetland Reserve Program participants should be encouraged to occasionally till dry temporary wetland basins because of the value of farmed temporary wetlands as breeding sites to Missouri River alluvial valley amphibian communities.

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**Study No. 18:** Wetland Ecology Studies in the Missouri River Floodplain

**Job No. 2:** Herpetofaunal communities of Missouri River floodplain wetlands:  
dynamics of prey for riverine birds and mammals

#### **Objectives:**

1. Determine the species composition and relative abundance of adult amphibian communities using new connected, new non-connected, temporary, wooded, and remnant wetlands on the Missouri River floodplain during 2-6 years following the 1993 flood.
2. Determine the amount and success of amphibian reproduction within new connected, new non-connected, temporary, wooded, and remnant wetlands on the Missouri River floodplain during 2-6 years following the 1993 flood.
3. Determine if the presence or absence, and relative abundance of adult and larval amphibians within new connected, new non-connected, temporary, wooded, and remnant wetlands are related to wetland characteristics of hydroperiod, aquatic macrophyte abundance, size, and wading bird and fish abundance.

4. Determine the species composition and relative abundance of turtle communities using new connected, new non-connected, temporary, wooded, and remnant wetlands on the Missouri River floodplain during 2-6 years following the 1993 flood.
5. Determine if the presence or absence, and relative abundance of turtles within new connected, new non-connected, temporary, wooded, and remnant wetlands are related to wetland characteristics of hydroperiod, aquatic macrophyte abundance, size, and wading bird and fish abundance.
6. Determine if selected species of turtles move equivalent amounts and distances around and among new connected, new non-connected, temporary, wooded, and remnants wetlands on the Missouri River floodplain during 2-5 years following the 1993 flood.

### **Introduction:**

The lower Missouri River and its alluvial valley have been greatly altered during the past century. Historically, the river was a wide, braided channel that consumed its banks, deposited new sediment, and unpredictably changed its channel (Hesse et al. 1989, Galat et al. 1996). The floodplain, the portion of the alluvial valley closest to the river, with its backwater sloughs, chutes, side channels, and ridge and swale topography, was inundated on average about every 1.5 to 2 years, and the timing and duration of water in these aquatic habitats were most influenced by the river. While still occasionally influenced by the river, higher and more river-distant terraces (floodplains

abandoned by the river (Leopold 1994)) with marshes and shallow wetlands were inundated only by extreme flood events, and the timing and duration of water in these basins was driven by local precipitation and subsurface water movement. Since the completion of the Pick-Sloan Plan in 1963 and the concurrent channelization and stabilization of the lower river, an estimated 41,000 ha of aquatic habitat has been lost through drainage, filling, and conversion of the alluvial valley for agriculture (Hesse et al. 1989). The taming of the Missouri River has shortened the lower river reach by 74 km (Funk and Robinson 1974), eliminated 50% of the water surface area (Funk and Robinson 1974), and now only 10% of the alluvial valley is periodically inundated by the river (Hesse et al. 1989). At present, the alluvial valley is now highly developed for agriculture and is largely a terrestrial system rather than a wetland system.

The Great Missouri River Flood of 1993 created 466 new wetlands on the 296 km long alluvial valley between Kansas City, MO and St. Louis, MO (SAST 1994, Galat et al. 1997). These new wetlands were created as floodwaters broke through levees and scoured holes that were often 7 to 15 m deep behind the levee breaks (SAST 1994, Galat et al. 1997). As the floodwaters receded, water remained in these new basins and they were available for colonization and use by flora and fauna.

The new wetlands in the Missouri River alluvial valley were of great interest to scientists in the region. Scientists in a multi-agency, cooperative effort called the Missouri River Post-flood Evaluation Project (MRPE) joined forces to determine if these new wetlands contributed suitable habitat to various plant and animal groups existing in the river and in the alluvial valley (Galat et al. 1998). Researchers have been examining limnological characteristics, plant communities, and various animal communities (zooplankton, macroinvertebrates, fish, amphibians, turtles, and birds) at these new wetlands as well as comparing them to plant and animal communities at wetlands that

existed prior to the flood, and remained after floodwaters receded.

Amphibians are major vertebrate components of wetland systems and can readily colonize new wetlands. Amphibians will appear around a new wetland within the first several years after its creation (Boomsma and Arntzen 1985, Sewell 1989, Laan and Verboom 1990, Arntzen and Teunis 1993, Sexton et al. 1998, Baker and Halliday 1999). Amphibian reproduction may even occur within the first several years of wetland creation, but it takes time for the amphibian community to build in numbers and diversity to a level resembling natural wetlands (Monello and Wright 1999). Amphibian use of a new wetland depends upon the species inhabiting nearby wetlands, the distance between the new wetland and existing wetlands, habitat surrounding the new wetland, and the physical and biological characteristics of the wetland, such as hydroperiod and the presence of fish (Laan and Verboom 1990, Baker and Halliday 1999).

Freshwater turtles can also be a significant component of wetland communities in the Missouri River alluvial valley. They are both predators of (insects and fish) and prey for (mammals and birds) other animals of the alluvial valley. Turtles use aquatic habitats for feeding, basking, and overwintering (Ernst et al. 1994). Because turtles are mobile, they are likely to colonize new wetlands quickly.

The goal of our research was to compare turtle and amphibian use of new, flood-created wetlands to turtle and amphibian use of existing wetlands in the lower Missouri River alluvial valley. Specifically, we compared the species composition and relative abundance of turtle and amphibian communities around and within six (two new versus four existing) wetland types during 1996 through 1998. We also identified habitat or landscape features that appeared to predict turtle and amphibian relative abundance and use at these wetlands.

The remainder of this document reports the results of the amphibian components of this



project. See included reports by Bodie (1998), Bodie et al. (2000), and Bodie and Semlitsch (2000) for results of the turtle components of the project.

### **Study Region:**

We examined amphibian communities at 24 wetlands of six types on the Missouri River alluvial valley from Sandy Hook, MO to Missouri City, MO (approximately 38° 47' 30" N and 92° 24' 30" W to 39° 16' N and 94° 15' W; river km 254 to 550; wetland locations are listed in Appendix A). The wetlands were scattered across the study region, and were no less than 0.5 km and no more than 37 km apart. These 24 wetlands were randomly selected from a list of wetlands observed in aerial surveys conducted immediately following the flood of 1993. We sampled four wetlands ( $n = 4$ ) of each of the six following types: farmed temporary, unfarmed temporary, wooded slough, remnant, non-connected scour, and connected scour.

The existing wetland types in the alluvial valley consisted of farmed temporary, unfarmed temporary, wooded slough, and remnant wetlands. Farmed temporary wetlands (palustrine; temporarily flooded or seasonally flooded; farmed (Cowardin et al. 1979)) were located in agricultural fields, typically held water in the spring and early summer, and dried by June or July. When these basins were dry, they were tilled and planted. During 1996 through 1998, these wetlands were tilled at least once. Unfarmed temporary wetlands (palustrine; temporarily flooded or seasonally flooded (Cowardin et al. 1979)) also held water in the spring and dried by June or July. These basins were in agricultural fields prior to 1993 and generally were not tilled after the flood. None were tilled after 1995 because they were purchased by state or federal government agencies or enrolled in the Wetland Reserve or Emergency Wetland Reserve Program of the U.S. Dept. of Agriculture following the 1993 flood. Wooded sloughs (palustrine; scrub-shrub vegetation or open water; broad-leaved deciduous; seasonally flooded or intermittently exposed (Cowardin et al. 1979))

were old river side channels that were typically isolated from the river except during occasional high river levels. Wooded sloughs were generally bordered by cottonwood (*Populus deltoides*) and willow (*Salix* spp.) trees. Remnant wetlands (palustrine; persistent emergent vegetation or open water; semipermanently or permanently flooded or intermittently exposed (Cowardin et al. 1979)) were old river oxbows or side channels at which the dominant perimeter vegetation was bullrush (*Scirpus* spp.), cattail (*Typha* spp.), and willow.

Both types of scour wetlands were created by the 1993 flood. Non-connected scour wetlands (lacustrine; limnetic; unconsolidated bottom; permanently flooded (Cowardin et al. 1979)) were created because of breaks in interior levees in the alluvial valley (Galat et al. 1997). These deep, initially unvegetated basins were 0.2 to 1.0 km from the river and were not normally connected to the river except during major floods. Connected scour wetlands (palustrine; unconsolidated bottom; mud; semipermanently flooded (Cowardin et al. 1979)) were created because of breaks in levees parallel and adjacent to the river (Galat et al. 1997). These initially unvegetated basins were connected to the river in the spring and early summer because of higher river levels at those periods, with river water freely moving in and out of the basin. Usually, these basins became disconnected from the river when the river level dropped in July or August. During the course of this study, the connected scour basins began to fill with sediment and debris brought into the basins with higher river levels.

Prior to the 1993 flood, the landscape in the alluvial valley was comprised of approximately the following proportion of land uses: 75% in agriculture, 10 % in forest, 13% in water (the river and wetlands), and 2% in early successional habitat such as sand and grass (based on 1978 information for a representative portion of the alluvial valley; D. Galat and M. Lastrup, pers. comm.). For some portions of the alluvial valley following the 1993 flood, it was not cost-effective to return the land

to agricultural uses. By 2000, state and federal agencies had purchased or enrolled into federal programs approximately 35,458 ha of this flood-impacted land for fish and wildlife habitat (D. Galat and M. Laustrop, pers. comm.).

### **Methods:**

To determine the species composition and relative abundance of amphibians at the study wetlands we sampled the amphibian communities using terrestrial drift fences (Gibbons and Semlitsch 1982) with their associated funnel traps. The aluminum drift fences were 7.5 m long, about 60 cm tall, and were buried approximately 10 cm in the ground. Two double-ended funnel traps were placed on either side of the fence mid-sections, and two single-ended funnel traps were placed at the ends of each fence. Each fence with its four associated funnel traps was considered to be a trap. Every study wetland was sampled with at least four traps. Study wetlands greater than 20 ha in water surface area received additional traps at a rate of one trap per five ha of surface area. Traps were randomly placed around the perimeter of each wetland. Traps were erected approximately 4.6 m landward from and parallel to the wetland edge. Trap location at a wetland remained the same during 1996 through 1998, although occasional flooding sometimes forced us to move fences to remain approximately 4.6 m from the wetland edge.

Traps were opened at wetlands in mid-February and closed in late May of each year. In 1996, we sampled amphibian communities during 19 February through 31 May; in 1997, from 18 February through 30 May; and in 1998, 5 February through 22 May. We defined the number of trap days at a wetland as the product of the number of traps and the number of days traps were open at that wetland. We checked traps at a wetland approximately every two to four days depending upon travel conditions, amphibian activity, and flooding. Amphibians captured within traps were identified to

species, marked with a unique mark, and released within 2 m of the trap where captured. The number of trap days per year for each wetland is listed in Appendix A.

We calculated amphibian relative abundance estimates for each wetland for each year. We defined relative abundance as the number of unique amphibian captures at a wetland divided by the number of trap days in the year for that wetland, then multiplied that result by 100. Relative abundance was expressed as the number of captures per 100 trap days. We used these estimates in Tukey's tests (SAS 1989) to determine if wetland types differed in amphibian relative abundance within a year. The test result was considered significant if  $P \leq 0.05$ . We also calculated mean relative abundance values for each species by wetland type during the three-year period. Because mean relative abundance values were small for most species, we made only qualitative comparisons about individual species use of wetland types.

To estimate the relative abundance of larval amphibians within the study wetlands we sampled the larval amphibian communities during mid-May through June of each year. If a wetland contained water during this period, we sampled for larval amphibians at the wetland for two consecutive days through the use of funnel traps suspended from drift fences within wetlands. Funnel traps (modified from Richter 1995) were constructed from plastic two-liter beverage containers and suspended from 5m long by 0.9 m wide sections of silt fencing material (Enge 1997) staked in  $\leq 1$  m deep water. Two funnel traps were suspended from each side of the fence resulting in four funnel traps for each fence. On each fence side, one funnel trap was suspended 20 cm from the wetland substrate, while the other funnel trap was suspended 75 cm from the substrate or 10 cm from the wetland surface if the water was  $< 75$  cm deep. We did this to account for any vertical migrations amphibian larvae might make during a 24 hr period (Anderson and Graham 1967). Wetlands were sampled in a random order without regard to the amount of water within a wetland.

A fence with its associated four funnel traps was defined as a trap. Each wetland was sampled with the same number of traps as were used for adult amphibian sampling. Larval traps were set in the water opposite the terrestrial traps and placed so that the fence was parallel to the shore. Larvae were emptied from traps each day, identified to species, if possible, and counted. The number of trap days per year for each wetland is listed in Appendix A.

Data from the larval sampling were summarized to calculate the number of larvae captured per trap day for each wetland in each year. These estimates were used in one-way analysis of variance of ranked data tests (Statxact 3 1996) to determine if larval relative abundance differed among wetland types within years. Because larval amphibian relative abundance appeared to be greatest in farmed temporary wetlands compared to other wetland types, we used one-way analysis of variance of ranked data tests (Statxact 3 1996) to determine if larval relative abundance differed among unfarmed temporary, wooded slough, remnant, non-connected and connected scour wetland types within each year. Larval amphibian relative abundances did not differ among the five wetland types in any year (1996,  $F=5.9$ ,  $P=0.16$ ; 1997,  $F=3.3$ ,  $P=0.52$ ; 1998,  $F=2.6$ ,  $P=0.91$ ). We then used Kolmogorov-Smirnov two-sample tests (Statxct 3 1996) with a Bonferroni correction to the alpha ( $\alpha/\text{number of contrasts} = 0.05/2$ , Stevens 1992, to reduce the chance of obtaining spurious results because of the number of contrasts made within a year) to test if larval relative abundance had differed between farmed temporary wetlands and all other wetland types combined within a year. The test result was considered significant if  $P \leq 0.025$ . Although we made a qualitative comparison of the species composition of larval amphibian communities among wetland types, we recognize that two days of trapping at a wetland during late May through June was not a sufficient sampling effort to characterize the species composition of the entire larval amphibian community that may have inhabited the wetlands during the entire breeding season.

To determine what habitat or landscape features might predict amphibian relative abundance within and around wetlands, we used scatter plots, Spearman's rank correlation, and stepwise regression (SAS 1989) to examine possible interrelationships between amphibian relative abundance and the following habitat or landscape features: wetland hydroperiod, wetland productivity, wetland distance from the river, wetland type, wetland distance from a refuge, wetland distance from the bluff, and prevalence of fish. Wetland hydroperiod can be an important factor determining amphibian use and success at a wetland (Pechmann et al. 1989). In this study, wetland hydroperiod was defined as the number of days water was in a wetland during the period of 20 February through 31 August (a 194 day period). This period of time was selected because all the amphibians that might breed in the Missouri River alluvial valley breed during this portion of the calendar year (Johnson 2000). Wetland productivity was defined as the mean amount of chlorophyll a (in ppb) in water samples collected from study wetlands during May and June of 1996 through 1998 (K. Bataille, unpub. data). Wetland distance from the river was defined as the shortest straight-line distance in km between the Missouri River and the study wetland. Wetland type was the category (e.g. farmed temporary) of wetland as earlier defined. We defined wetland distance from a refuge as the shortest straight-line distance between the wetland and a potential undisturbed, non-breeding season refuge for amphibians. Potential refuges could be undisturbed upland vegetation around a wetland, a fence line in a tilled agriculture field, or untilled ground beneath a tree in an agricultural field. Wetland distance to the bluff was defined as the shortest straight-line distance between the wetland and the base of the bluff, which marks the natural boundary of the Missouri River alluvial valley. We defined fish prevalence as the percentage of years during the study in which fish were known to be present at a wetland (K. Bataille, unpub. data).

To gain initial impressions of the influence of these habitat or landscape features upon

amphibian use, we plotted the two dependent variables, mean amphibian relative abundance and mean larval amphibian relative abundance during 1996-1998 per wetland, against values for the habitat and landscape features. We then examined the Spearman's rank correlations between the dependent variables and the habitat and landscape features. To guard against spurious significant correlations, we used a Bonferroni correction ( $\alpha/\text{number of variables} = 0.05/7$ , Stevens 1992) and regarded correlations as significant if  $P \leq 0.007$ . Habitat and landscape features (wetland type, fish prevalence, distance to river, and hydroperiod) that were related to dependent variables in scatter plots and correlation analysis were further used in stepwise regression to determine which features best predicted amphibian and larval amphibian relative abundance. Features which resulted in significant ( $P \leq 0.05$ ) regressions with large  $R^2$  values (proportion of the variability) and small  $C_p$  values (a measure of total squared error in the model) were considered to predict amphibian use of wetlands in the lower Missouri River alluvial valley.

## **Results:**

We captured thirteen amphibian species around wetland perimeters during 1996 through 1998 (Table 1; see Appendix B for a list of species' relative abundance estimates by wetland and year). The composition of communities around farmed and unfarmed temporaries, wooded slough, remnant, and non-connected scour wetlands was similar. Nine species were observed in each of these wetland types. We captured the fewest number of species (seven) around connected scour wetlands. The most abundant species were Woodhouses' toad, western chorus frogs, and plains leopard frogs (Table 1). We captured greater numbers of these species at farmed and unfarmed temporaries, wooded sloughs, and non-connected scours than at remnant and connected scour wetlands. Other amphibian species were as widely dispersed as the above three species, but were

not captured in such great numbers. Smallmouth salamanders, the only salamander to be consistently captured during this study, were captured around all wetland types except connected scours (Table 1). We observed the greatest mean relative abundance of amphibians at farmed and unfarmed temporaries, wooded sloughs, and non-connected scour wetlands in most years (Table 2).

We captured thirteen species of larval amphibians within the six wetland types (Table 3; see Appendix C for a list of species' relative abundances by wetland and year). Eleven of the thirteen species were captured in farmed temporary wetlands. We also captured a moderate (six to eight) number of species within unfarmed temporary, wooded slough, and remnant wetlands. The larval amphibian communities within the flood-created non-connected and connected scour wetlands were depauperate compared to the communities at the four other wetland types. Smallmouth salamander and plains spadefoot larvae were captured only within farmed temporary wetlands. Great Plains narrow-mouth toad (*Gastrophryne olivacea* (Hallowell)) and green frog (*Rana clamitans melanota* (Rafinesque)) larvae were captured only in a remnant wetland. The remaining nine species of amphibians appeared to be more flexible in use of wetland types, except the flood-created wetlands, as breeding sites.

The amphibian species whose distributions are restricted to the Missouri River alluvial valley within Missouri, Great Plains toad and plains spadefoot (Johnson 2000), were captured as adults only at farmed and unfarmed temporaries, non-connected scours, and wooded sloughs (Table 1). Of the two species, only plains spadefoot larvae were captured and those larvae were captured at a farmed temporary wetland (Table 3). Even though these species may explore and forage around other wetland types, we think both species are likely to restrict their breeding to temporary wetlands in the Missouri River alluvial valley, just as they restrict their breeding to temporary wetlands in other portions of their range (Bragg 1940a, Bragg 1945).



Larval amphibian relative abundance differed among wetland types in 1997 and tended to differ in 1996 (Table 4). We captured more larval amphibians at farmed temporary wetlands than at other wetland types in 1997 ( $D=0.75$ ,  $P=0.008$ ). We also tended to capture more larva in farmed temporary wetlands in 1996 ( $D=0.63$ ,  $P=0.05$ ) and 1998 ( $D=0.64$ ,  $P=0.029$ ). Even though relative abundance estimates at farmed temporary wetlands displayed great annual and among wetland variation, this wetland type appears to be highly used as an amphibian breeding site in the Missouri River alluvial valley based upon the number of species and larvae captured in that wetland type.

In plots of amphibian and larval amphibian relative abundance against wetland variables, we noted wetland hydroperiod was related to both amphibian and larval relative abundance in a quadratic function (Fig. 1). Under short and long hydroperiods, values for amphibian relative abundance were small, yet for wetlands with hydroperiods of 80 to 140 days, the values of amphibian abundance were greater. In correlation analyses, we observed that the prevalence of fish in a wetland and adult amphibian abundance were negatively related ( $r = -0.56$ ,  $P=0.005$ ,  $n=24$ ). We also noted that the distance from the wetland to the Missouri River was positively correlated to larval amphibian abundance ( $r=0.61$ ,  $P=0.001$ ,  $n=24$ ). Wetland productivity, distance to a refuge, and distance to bluff were not related to amphibian abundance in scatter plots or correlation analyses.

In stepwise regression, wetland type and fish prevalence best predicted amphibian abundance ( $R^2 = 0.76$ ,  $F = 33.82$ ,  $P = 0.0001$ ). We think it might be easier for managers to document the hydroperiod of a wetland than to document the prevalence of fish in a basin. We noted that in Spearman's rank correlation, the prevalence of fish and wetland hydroperiod were highly correlated ( $r = 0.73$ ,  $P = 0.0001$ ). For the above reasons, we deleted fish prevalence from the stepwise regression process and noted that wetland type and the hydroperiod quadratic term also predicted

amphibian abundance ( $R^2 = 0.71$ ,  $F = 25.8$ ,  $P = 0.0001$ ). Wetland type and the distance to the river were variables producing the best regression for larval amphibian abundance ( $R^2 = 0.65$ ,  $F = 19.09$ ,  $P = 0.0001$ ). From the scatter plot, correlation, and stepwise regression results, we conclude that amphibian relative abundance at a wetland could be predicted by the variables of wetland type and fish prevalence (or wetland hydroperiod if it is more easily measured), and larval amphibian relative abundance could be predicted by wetland type and distance from the wetland to the Missouri River.

We think that if the wetland is a farmed temporary with a hydroperiod of about 80 to 140 days between 20 February and 31 August or the wetland never or rarely has fish, the wetland should attract large numbers of amphibians. In addition, if a wetland is a farmed temporary and far (perhaps at least 1.5 km) from the river, the wetland likely will be a good amphibian breeding site with periodically great numbers of larval amphibians.

### **Discussion:**

All wetland types, except connected scour wetlands, studied in the Missouri River alluvial valley attracted the same amphibian species and a similar number of amphibians around their perimeters. The greatest difference in amphibian use among these wetland types was in larval amphibian communities. We usually captured large numbers of larvae in farmed temporary wetlands. From other studies, we know there can be great annual variation in amphibian production within a basin (Heyer 1976, Pechmann et al. 1989) because of varying basin hydroperiods (Pechmann et al. 1989), varying numbers of adults that come to the basin (Pechmann et al. 1991), or a number of other physical and biological factors (Heyer 1979, Semlitsch 2000). We doubt a farmed temporary wetland in the Missouri River alluvial valley would annually be filled with amphibian larvae because of natural variations in climate and animal numbers, but as a group, the farmed temporary wetlands were important amphibian breeding sites during this study.

The farmed temporary wetlands in this study were important probably because of their location in the alluvial valley and hydroperiod. These wetlands tended to be further from the Missouri River (farmed temporary  $\bar{X}$  distance from river = 1.9 km; range = 0.5 to 3.2 km) than most other wetland types ( $\bar{X}$  distance = 1.0 km; range = 0.0 to 3.1 km). We think being further from the river implies that these wetlands are less likely to be flooded by the river or have a periodic connection to the river. This reduces the likelihood that the wetland will be invaded by fish, which are predators of amphibian eggs and larvae (Duellman and Trueb 1986). These farmed temporaries also had an intermediate-length hydroperiod that was appropriate for amphibian breeding. The egg laying to metamorphosis periods for the amphibians we captured, other than bullfrogs, ranges from a low of three to four weeks for plains spadefoot (Mabry and Christiansen 1991) to three months for plains leopard frogs and southern leopard frogs (Johnson 2000). Most species need water in the wetland for four to twelve weeks (Johnson 2000). Amphibians are likely to use wetlands that have a hydroperiod of intermediate-length because if the hydroperiod is too short, there is insufficient time for larvae to develop. If the hydroperiod is too long, the likelihood that the wetland will harbor fish and invertebrate predators increases (Duellman and Trueb 1986, Semlitsch 2000). Three of four farmed temporary wetlands that held large numbers of larval amphibians had a hydroperiod of 83 to 128 days. The farmed temporary wetland with few amphibian larvae had an average hydroperiod of 180 days and was only 0.5 km from the river.

We expected the unfarmed temporary wetlands in this study to contain great numbers of larval amphibians as well. However, we think these wetlands were less suitable for larvae because some had hydroperiods that may have been too long, while others were occasionally flooded or connected to the river and thus invaded by fish. At this point, we are uncertain what the role of tillage might be in making the farmed temporaries good larval amphibian habitat. We suggest this

question be further investigated to determine if disturbing the basin does make the habitat more suitable, or if the farmed temporary wetlands are suitable because of their location in the alluvial valley or some other factor.

Current thoughts about amphibian selection of wetlands include notions that amphibians typically occupy the most productive wetlands (Bragg 1940b, Duellman and Trueb 1986) and land use around wetlands influences amphibian use during the breeding season (Laan and Verboom 1990, Mensing et al. 1998, Monello and Wright 1999). In this study we did not observe a relationship between wetland productivity or distance to refuge and the abundance of amphibians captured at wetlands. Our human-defined refuges may not have been related to amphibian abundance because of amphibian abilities to dig into the ground or seek refuge in less obvious habitats such as crayfish burrows, cracks in the mud, and plant root zones (Bragg 1940a, Bragg 1944, Kramer 1973, Williams 1973, Semlitsch 1983) adjacent to wetlands. The farmed temporary wetlands with relatively abundant larvae had the lowest May and June chlorophyll a levels. Chlorophyll a levels were greatest at wooded slough and remnant wetlands, and while some amphibian breeding occurred at these types, these wetlands did not hold the great abundances of larval amphibians observed in farmed temporary wetlands. We suggest that these highly productive wetlands with greater chlorophyll a levels are less suitable because of the relative permanence of the water. More permanent waterbodies tend to be occupied by fish and invertebrate predators of amphibians (Duellman and Trueb 1986, Semlitsch 2000). Another reason why we may not have observed a positive relationship between amphibian abundance and productivity is that the farmed temporary wetlands may have had suppressed chlorophyll levels because larvae were eating so much of the suspended algae. For instance, Seale (1980) described a situation where tadpoles significantly reduced primary production in a pond. Unfortunately, we can not determine if amphibian larvae in

this study might have reduced primary productivity because data were not collected to answer that question.

In their third through fifth years since creation, flood-created connected scour and non-connected scour wetlands appear to be of little value for amphibians. While we did capture amphibians around their perimeters and an occasional larvae within the basins, these wetlands are not likely to be sites with abundant amphibian larvae because they contain fish. In time as the emergent and submergent vegetation within the lake-like non-connected scours develop, we suspect more amphibians may lay eggs in these basins, but these species likely will be ones that are unpalatable to fish (e.g. bullfrogs, American toads; Kruse and Francis 1977, Brodie et al. 1978, Formanowicz and Brodie 1982, Kats et al. 1988) or have behavioral defense mechanisms in the presence of fish predators (e.g. Blanchard's cricket frogs, gray treefrogs; Kats et al. 1988). Connected scour wetlands likely will never be important amphibian breeding sites because they are gradually filling with silt and debris, and are readily accessible to fish.

Since the 1993 flood, there has been a great deal of discussion about restoring sections of the Missouri River alluvial valley and the river's hydrograph to a more "natural condition" to benefit fish and wildlife resources of the Missouri River basin (Galat et al. 1996, Galat et al. 1998). One might think there is a conflict when discussing amphibian breeding habitat needs and the habitat needs of native riverine fish, such as pallid sturgeon (*Scaphirhynchus albus* (Forbes and Richardson)), a federally endangered species, buffalo (*Ictiobus* spp.), and goldeyes (*Hiodon alosoides* (Rafinesque)) that would benefit from reconnecting the river and floodplain, and the restoration of the historical timing and duration of flooding. If the Missouri River was allowed to reconnect with the floodplain on an one-in-two or three year basis and the river's hydrograph was allowed to fluctuate at levels and around dates resembling historical conditions, it would appear that

the amphibian community might be greatly impacted with the annual introduction of fish into wetlands because of widespread flooding in the alluvial valley. However, we suggest that the restoration of the historical hydrograph, and reconnection of the river and alluvial valley would not adversely impact amphibian reproductive efforts because the timing of the historical flooding and most amphibian breeding efforts are different. We think the majority of the Missouri River system amphibian species lay eggs and larvae metamorphose during late February through late May (Johnson 2000) before the historical peak of flooding in June (Galat and Lipkin 1999). We think the fish-intolerant species, such as western chorus frog, plains spadefoot, northern spring peepers, and plains leopard frogs (Kats et al. 1988) are likely to have left the temporary wetlands prior to the river covering the lower portions of the alluvial valley. We also suggest that the historical flooding probably did not always cover the entire alluvial valley with every June peak (Fig. 2, R. Jacobson, pers. comm.) just as the Great Flood of 1993 did not cover the entire alluvial valley (SAST 1994), and thus fish-less temporary wetlands are annually available to breeding amphibians somewhere on the floodplain and alluvial valley. Wetlands furthest away from the river and located upon higher terraces are likely to be invaded by fish only in extreme flood events. Others have noted that amphibian use of wetlands in a large river system floodplain increases as the likelihood of inundation by the river decreases (Tockner et al. 1998). We think there would still be amphibian breeding places in the alluvial valley if the river was once again allowed to reconnect with the floodplain and rise to magnitudes and durations resembling historical peaks.

Another implication of this research is relevant to the application of the Wetland Reserve Program (WRP) within the U.S. Department of Agriculture. In this program, landowners can enroll eligible land into WRP and be financially compensated for the restoration and protection of wetlands. Current WRP guidelines call for the restoration of the original hydrology and vegetation.

Participants in WRP must manage the land according to a Wetlands Reserve Plan of Operations, which can allow management and disturbance of the vegetation. Although WRP is designed to provide wetland benefits to a wide range of species, there is no incentive for the landowner to do intensive management or manipulation of vegetation. Although we do not totally understand the role of disturbance (i.e. tillage) in making the farmed temporary wetlands suitable for amphibian breeding, we suggest WRP participants should be provided with a financial incentive to manage temporary basins through occasional tillage. Until research more clearly explains how and if occasional tillage is or is not beneficial to breeding amphibian communities, these results suggest that occasional tillage of basins in dry years with the resulting setback of the plant community, is not of harm to the amphibian community.

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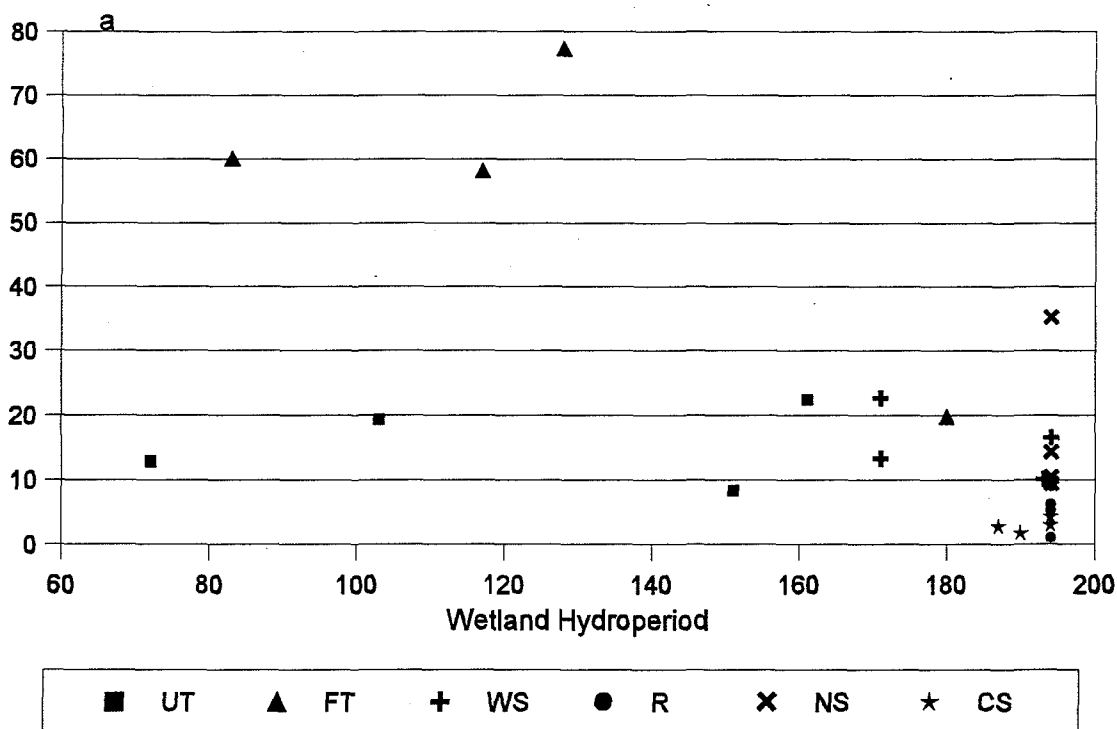
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Figure 1. Plots of mean amphibian relative abundance (a) and mean larval amphibian relative abundance (b) per wetland against wetland hydroperiod during 1996-1998. Values are plotted by wetland type: UT = unfarmed temporary; FT = farmed temporary; WS = wooded slough; R = remnant; NS = non-connected scour; CS = connected scour.

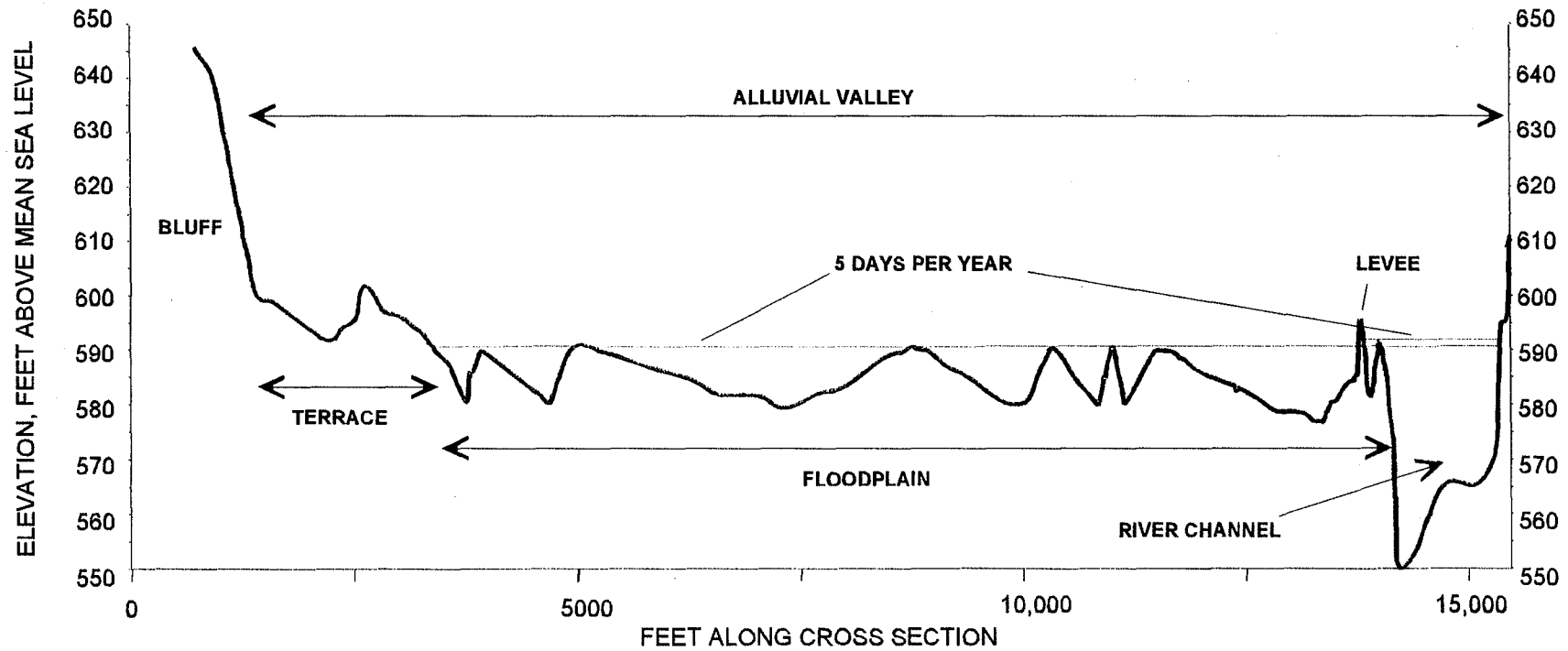
Figure 2. A cross section diagram of the lower Missouri River alluvial valley at Boonville, Missouri, USA. The alluvial valley is composed of the river channel, floodplain, and terrace. The red line represents the greatest extent of typical annual river flooding, which occurred on average five days per year, within the alluvial valley prior to the development of the Pick - Sloan project. The blue line represents the greatest extent of typical annual flooding, which also occurs on average five days per year, since the completion of the Pick - Sloan project.

Mean amphibian abundance (captures/100 trap days)





# CROSS SECTION OF MISSOURI RIVER ALLUVIAL VALLEY AT BOONVILLE, MISSOURI



POST-REGULATION, POST-LEVEE WATER LEVELS IN BLUE  
PRE-REGULATION, PRE-LEVEE WATER LEVELS IN RED

Table 1. Mean relative abundance estimates (captures/100 trap days) for amphibian species captured at six wetland types on the Missouri River alluvial valley during 1996 through 1998. Standard errors are in parentheses. Scientific names are listed below the common name.

Amphibian Species	Wetland Type					
	farmed temporary	unfarmed temporary	wooded slough	remnant	non-connected scour	connected scour
smallmouth salamander	0.24 (0.06)	0.26 (0.26)	0.13 (0.06)	0.30 (0.30)	0.09 (0.09)	0.0
<i>Ambystoma texanum</i> (Matthes)						
tiger salamander	0.0	0.02 (0.02)	0.0	0.0	0.0	0.0
<i>Ambystoma tigrinum tigrinum</i> (Green)						
Blanchard's cricket frog	0.39 (0.09)	1.12 (0.59)	1.14 (0.21)	0.31 (0.16)	0.89 (0.28)	0.16 (0.08)
<i>Acris crepitans blanchardi</i> Harper						
American toad		1.1 (0.38)	0.63 (0.13)	0.38 (0.32)	0.14 (0.07)	0.39 (0.24) 0.45 (0.16)
<i>Bufo americanus americanus</i> Holbrook						
Great Plains toad	0.15 (0.08)	0.02 (0.02)	0.02 (0.02)	0.0	0.06 (0.04)	0.0
<i>Bufo cognatus</i> Say						

Table 1. Continued.

Amphibian Species	Wetland Type					
	farmed temporary	unfarmed temporary	wooded slough	remnant	non-connected scour	connected scour
Woodhouses' toad	7.8 (2.1)	2.9 (1.0)	3.1 (1.6)	0.3 (0.2)	10.2 (5.0)	1.1 (0.3)
<i>Bufo woodhousei woodhousii</i> Girard						
gray treefrog	0.71 (0.33)	1.0 (0.36)	0.71 (0.28)	0.2 (0.03)	0.02 (0.02)	0.02 (0.02)
<i>Hyla chrysoscelis</i> - <i>Hyla versicolor</i> Complex						
n. spring peeper		0.51 (0.51)	0.28 (0.16)	0.0	0.0	0.03 (0.03) 0.0
<i>Pseudacris crucifer crucifer</i> (Wied)						
w. chorus frog		27.2 (9.0)	7.1 (1.8)	7.7 (2.7)	1.6 (0.7)	1.6 (0.7) 0.6 (0.3)
<i>Pseudacris triseriata triseriata</i> (Wied)						
plains leopard frog	6.6 (1.9)	2.07 (0.58)	2.2 (0.8)	0.93 (0.37)	3.5 (1.1)	0.29 (0.12)
<i>Rana blairi</i> Meham, Littlejohn, Oldham, Brown and Brown						

Table 1. Continued.

Amphibian Species	Wetland Type					
	farmed temporary	unfarmed temporary	wooded slough	remnant	non-connected scour	connected scour
bullfrog	0.27 (0.14 )	0.02 (0.02)	0.04 (0.03 )	1.1 (0.53)	0.08 (0.03)	0.0
<i>Rana catesbeiana</i> Shaw						
s. leopard frog	0.79 (0.68)	0.44 (0.12)	0.24 (0.05)	0.48 (0.27)	0.42 (0.12)	0.17 (0.08)
<i>Rana sphenoccephala</i> Cope						
plains spadefoot	0.18 (0.13)	0.02 (0.02)	0.0	0.0	0.06 (0.04)	0.0
<i>Spea bombifrons</i> (Cope)						

Table 2. Mean amphibian relative abundance estimates (captures per 100 trap days) by wetland type and year for wetlands on the Missouri River alluvial valley during 1996 through 1998.

Standard errors of the estimates are in parentheses.

Wetland type	Year		
	1996	1997	1998
Farmed temporary	10.8 (6.2) A <sup>a</sup>	45.3 (13.8) A	81.8 (21.7) A
Unfarmed temporary	8.3 (1.2) A	25.0 (5.8) AB	14.1 (5.8) AC
Non-connected scour	9.3 (3.3) A	16.8 (4.7) AB	25.8 (14.0) AB
Connected scour	1.9 (0.8) A	5.7 (1.5) B	1.1 (0.5) C
Wooded slough	13.2 (3.3) A	19.2 (0.8) AB	14.6 (5.9) AC
Remnant	3.2 (1.4) A	8.2 (2.5) B	4.7 (1.4) BC

<sup>a</sup> Means within a year with the same letter are not significantly different in Tukey's tests.

Table 3. Species of larval amphibians captured within six wetland types on the Missouri River alluvial valley during 1996 through 1998. An X in the column denotes a capture of that species within a wetland type.

Species	Farmed temp	Unfarmed temp	Wooded slough	Remnant	Nonconnected scour	Connected scour
small-mouthed salamander	X					
Blanchard's cricket frog	X		X			
e. American toad	X		X			
Woodhouse's toad	X	X	X	X		X
gray treefrog	X		X	X		
n. spring peeper	X	X		X		
w. chorus frog	X	X	X			
plains leopard frog	X	X	X	X		X
bullfrog	X	X	X	X	X	
green frog		X				
s. leopard frog	X	X	X	X		
plains spadefoot	X					
Gt. Plains narrow-mouth toad				X		

Table 4. Mean relative abundance estimates of larval amphibians (captures per trap day) by wetland type and year on the Missouri River alluvial valley during 1996 through 1998. Sample size for each wetland type is four except where noted. Standard errors of estimates are in parentheses.

Wetland type	Year		
	1996 <sup>a</sup>	1997 <sup>b</sup>	1998 <sup>c</sup>
Farmed temporary	6.2 (4.8)	53.7 (43.0)	20.0 (18.6)
Unfarmed temporary	0.5 (0.4)	1.5 (0.9)	0.1 (0.1)
Non-connected scour	0.0 (0.0)	0.5 (0.5)	0.0 (0.0)
Connected scour	— <sup>d</sup>	0.0 (0.0)	0.3 (0.2) <sup>e</sup>
Wooded slough	1.1 (0.8)	0.8 (0.8)	3.6 (3.6)
Remnant	0.5 (0.3)	0.5 (0.5)	5.2 (5.2)

<sup>a</sup> One-way analysis of variance of ranked data test results : F=5.1, P=0.09.

<sup>b</sup> One-way analysis of variance of ranked data test results : F=6.8, P=0.009.

<sup>c</sup> One-way analysis of variance of ranked data test results : F=4.2, P=0.45.

<sup>d</sup> Connected scour wetlands were not sampled because of flooding in 1996.

<sup>e</sup> Only two connected scour wetlands were sampled in 1998 because of flooding.

Appendix A. Missouri River Post-flood Evaluation project wetland location (in UTM coordinates in zone 15 and using NAD 1983 datum) and number of trap days per year for each wetland.

	Wetlands								
	PTA	PT	T4	LT	TC/T8 <sup>1,2</sup>	T2	T13	T13A	W1
<u>Location</u>									
Easting	551060	550971	505045	507341	538874	511454	440777	435657	541858
Northing	4293844	4295260	4325846	4330273	4310071	4320230	4343122	4342279	4308919
<u>No. of terrestrial trap days</u>									
1996	364	402	366	345	167	180	172	200	396
1997	379	395	269	352	274	382	253	293	354
1998	396	396	412	402	396	226	386	395	378
<u>No. of larval trap days</u>									
1996	8	8	F <sup>3</sup>	8	8	8	D <sup>4</sup>	8	8
1997	8	8	8	D	4	8	8	8	8
1998	8	D	8	D	8	D	8	8	8
<u>Wetland Type<sup>5</sup></u>	UT	UT	UT	UT	FT	FT	FT	FT	WS
	Wetlands								
	W2	W3	W6C	E1	E2	E3	E5	NC4	
<u>Location</u>									
Easting	525152	511259	435153	497132	474957	415171	392759	533632	
Northing	4316285	4317395	4341278	4358330	4348170	4335782	4346504	4312743	
<u>No. of terrestrial trap days</u>									
1996	390	387	364	744	376	372	950	345	
1997	381	316	345	358	276	215	833	203	
1998	424	395	424	786	393	348	1050	332	
<u>No. of larval trap days</u>									
1996	8	8	8	16	8	8	20	8	
1997	8	8	8	16	8	8	20	8	
1998	8	8	8	16	8	8	20	8	
<u>Wetland Type</u>	WS	WS	WS	E	E	E	E	NS	



Wetlands							
	NC8	NC16	NC17	S13	S15	S19	S21
<u>Location</u>							
Easting	511229	420986	408382	505937	506246	501512	493777
Northing	4319144	4336794	4333084	4327202	4330189	4350968	4356141
<u>No. of terrestrial trap days</u>							
1996	375	335	352	320	455	538	340
1997	363	244	157	216	434	332	234
1998	424	424	424	332	367	617	408
<u>No. of larval trap days</u>							
1996	8	5	8	F	F	F	F
1997	8	8	8	8	8	12	8
1998	8	8	8	F	F	12	8
<u>Wetland Type</u>	NS	NS	NS	CS	CS	CS	CS

<sup>1</sup> Wetland T8 was sampled only in 1996; wetland TC replaced T8 as a sample site in 1997 and 1998.

<sup>2</sup> Wetland TC UTM coordinates are listed in appendix. Wetland T8 UTM coordinates are 498434 easting, 4354980 northing.

<sup>3</sup> F = Flooded wetland. We did not sample for larval amphibians if the wetland was flooded.

<sup>4</sup> D = Dry wetland. We did not sample for larval amphibians if the wetland was dry.

<sup>5</sup> Wetland Types: UT = Unfarmed temporary; FT = Farmed temporary; WS = Wooded slough; E = Emergent wetland; NS = Non-connected scour; CS = Connected scour.

Appendix B. Amphibian relative abundance estimates (captures/100 trap days) by species and all species combined (total

adults) for each wetland in the Missouri River Post-flood Evaluation Project during 1996, 1997, and 1998.

Wetland - Year	Species												Total
	ACCR <sup>1</sup>	AMTE	BUAM	BUCO	BUWO	HYCH	PSCR	PSTR	RABL	RACA	RASP	SCBO	
T8 <sup>2,3</sup> - 1996	-	-	-	-	-	1.20	-	-	-	-	-	1.20	2.40
TC - 1997	0.37	-	2.56	-	18.98	0.37	-	28.83	15.33	-	7.30	-	73.74
TC - 1998	0.76	0.76	-	-	20.45	0.51	-	54.04	4.55	-	-	-	81.07
T2 - 1996	-	-	5.00	1.11	7.22	-	-	0.56	-	-	-	-	13.89
T2 - 1997	0.52	0.79	0.25	-	4.19	2.36	0.79	17.02	6.02	0.26	0.52	0.52	33.24
T2 - 1998	-	0.44	1.33	-	5.31	1.77	5.31	116.81	2.21	-	-	-	133.18
T13 - 1996	-	-	-	-	-	-	-	-	-	-	-	-	0.00
T13 - 1997	1.19	0.40	1.19	0.40	2.77	-	-	3.16	3.16	0.40	-	-	12.67
T13 - 1998	-	-	0.26	-	10.10	-	-	3.63	12.18	0.78	-	-	26.95
T13A - 1996	1.00	-	-	-	17.00	-	-	2.50	5.00	-	0.50	1.00	27.00
T13A - 1997	0.34	-	2.05	-	4.78	0.68	-	49.15	4.10	-	-	0.34	61.44
T13A - 1998	0.51	0.51	0.51	0.25	2.03	2.79	-	50.89	26.58	1.77	-	0.25	86.09
PTA - 1996	-	0.27	0.27	-	3.57	-	-	1.65	0.55	-	-	-	6.31
PTA - 1997	3.43	2.63	1.32	-	2.37	2.37	1.32	20.84	5.28	0.26	1.85	-	41.93 <sup>4</sup>
PTA - 1998	4.80	0.25	-	-	0.25	1.01	0.51	9.60	3.03	-	-	-	19.45
PT - 1996	-	-	0.50	-	5.47	0.25	-	5.22	-	-	0.25	-	11.69
PT - 1997	1.01	-	-	-	8.59	1.52	-	5.81	1.26	-	0.76	-	18.95
PT - 1998	2.78	-	-	-	3.54	3.28	-	17.42	0.25	-	-	0.25	27.52

Species

Wetland - Year	ACCR <sup>1</sup>	AMTE	BUAM	BUCO	BUWO	HYCH	PSCR	PSTR	RABL	RACA	RASP	SCBO	Total
LT - 1996	0.58	-	1.73	0.29	2.60	-	-	2.31	-	-	0.58	-	8.09
LT - 1997	1.14	-	1.14	-	4.55	2.84	0.57	4.26	7.39	-	1.42	-	23.31
LT - 1998	-	-	-	-	-	1.00	1.00	3.73	1.49	-	-	-	7.22
T4 - 1996	-	-	0.28	-	1.91	-	-	4.92	-	-	-	-	7.11
T4 - 1997	-	-	1.73	-	1.38	-	-	7.61	5.19	-	-	-	15.91
T4 - 1998	-	-	-	-	0.97	-	-	0.73	-	-	0.49	-	2.19
W1 - 1996	0.76	0.25	-	-	0.25	1.01	-	18.18	2.02	-	0.25	-	22.72
W1 - 1997	1.13	-	0.28	-	1.98	0.28	-	9.32	4.80	-	0.57	-	18.36
W1 - 1998	1.59	-	-	-	1.06	0.53	-	18.78	4.76	0.26	-	-	26.98
W2 - 1996	0.26	-	0.26	-	2.56	0.77	-	6.92	0.77	-	0.51	-	12.05
W2 - 1997	3.15	0.26	-	-	4.72	0.52	-	6.56	2.10	-	0.52	-	17.83
W2 - 1998	0.94	0.24	-	-	0.47	0.47	-	7.31	0.47	-	-	-	9.90
W3 - 1996	0.78	-	-	-	2.07	1.29	-	4.39	1.55	-	0.78	-	10.86
W3 - 1997	3.48	0.32	-	-	1.27	3.16	-	10.13	0.63	-	-	-	18.99
W3 - 1998	-	0.51	-	-	-	-	-	-	-	-	-	-	0.51
W6C - 1996	0.55	-	-	-	2.20	-	-	1.10	2.75	0.27	0.27	-	7.14
W6C - 1997	0.58	-	4.06	0.29	8.99	0.29	-	5.80	1.45	-	-	-	21.46
W6C - 1998	0.47	-	-	-	12.03	0.24	-	3.30	4.95	-	-	-	20.99
E1 - 1996	-	-	-	-	-	-	-	-	0.13	0.67	1.34	-	2.14
E1 - 1997	-	-	0.28	-	-	0.56	-	2.23	1.96	3.63	1.40	-	10.06
E1 - 1998	0.25	-	-	-	-	-	-	0.76	0.13	1.53	1.02	-	3.69

Species

Wetland - Year	ACCR <sup>1</sup>	AMTE	BUAM	BUCO	BUWO	HYCH	PSCR	PSTR	RABL	RACA	RASP	SCBO	Total
E2 - 1996	-	-	-	-	-	-	-	-	-	-	0.27	-	0.27
E2 - 1997	-	-	-	-	0.36	-	-	-	-	0.36	0.72	-	1.44
E2 - 1998	-	-	-	-	-	0.51	-	0.25	-	0.25	0.25	-	1.26
E3 - 1996	-	-	-	-	1.34	-	1.88	-	-	-	0.54	-	3.76
E3 - 1997	1.86	-	0.47	-	0.47	0.47	-	0.93	3.26	0.47	-	-	7.93
E3 - 1998	0.29	-	-	-	0.86	-	-	3.74	2.01	-	-	-	6.90
E5 - 1996		0.53	1.26	0.53	-	0.42	0.32	-	2.21	1.16	0.11	0.21	-
	6.75												
E5 - 1997	0.48	1.32	0.24	-	-	0.36	-	7.08	2.16	1.68	-	-	13.32
E5 - 1998	0.29	1.05	0.19	-	0.10	0.19	-	0.38	0.38	4.48	-	-	7.06
NC4 - 1996	0.29	0.58	-	-	0.29	-	-	0.87	1.16	-	0.29	-	3.48
NC4 - 1997	2.46	0.49	-	-	4.43	-	-	5.42	1.97	0.49	0.99	-	16.25
NC4 - 1998	2.41	-	-	-	0.60	-	0.30	3.61	1.51	-	-	-	8.43
NC8 - 1996	1.87	-	-	-	7.20	-	-	1.07	6.40	0.27	1.33	0.27	18.41
NC8 - 1997	0.55	-	-	-	5.23	-	-	0.55	1.10	-	0.28	-	7.71
NC8 - 1998	-	-	-	-	4.72	-	-	-	0.24	-	-	-	4.96
NC16 - 1996	-	-	0.90	-	6.57	-	-	-	0.90	-	1.49	-	9.86
NC16 - 1997	0.41	-	0.82	-	7.38	-	-	4.51	16.39	-	0.41	-	29.92
NC16 - 1998	1.18	-	-	0.24	60.14	-	-	1.42	2.36	-	-	0.47	65.81
NC17 - 1996	0.28	-	0.57	0.28	2.56	-	-	-	1.42	-	0.28	-	5.39
NC17 - 1997	1.27	-	1.91	-	2.55	-	-	0.64	7.01	-	-	-	13.38
NC17 - 1998	-	-	0.47	0.24	20.75	0.24	-	0.71	1.42	0.24	-	-	24.07

Species

Wetland - Year	ACCR <sup>1</sup>	AMTE	BUAM	BUCO	BUWO	HYCH	PSCR	PSTR	RABL	RACA	RASP	SCBO	Total
S13 - 1996	-	-	-	-	0.94	-	-	0.94	0.63	-	0.31	-	2.82
S13 - 1997	0.46	-	2.78	-	2.31	-	-	3.24	0.46	-	0.46	-	9.71
S13 - 1998	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S15 - 1996	-	-	0.22	-	0.22	-	-	0.22	-	-	-	-	0.66
S15 - 1997	-	-	0.46	-	5.07	-	-	0.46	0.23	-	-	-	6.22
S15 - 1998	-	-	-	-	0.82	-	-	0.54	-	-	-	-	1.36
S19 - 1996	-	-	0.19	-	-	-	-	-	-	-	0.19	-	0.38
S19 - 1997	0.30	-	0.90	-	1.51	-	-	1.20	0.30	-	-	-	4.21
S19 - 1998	-	-	-	-	0.49	-	-	-	-	-	-	-	0.49
S21 - 1996	0.59	-	-	-	2.35	0.29	-	-	0.29	-	0.29	-	3.81
S21 - 1997	-	-	0.85	-	-	-	-	-	0.85	-	0.85	-	2.55
S21 - 1998	0.74	-	-	-	0.49	-	-	0.49	0.74	-	-	-	2.46

<sup>1</sup> - ACCR = *Acris crepitans blanchardi*; AMTE = *Ambystoma texanum*; BUAM = *Bufo americanus americanus*; BUCO = *Bufo cognatus*; BUWO = *Bufo woodhousii woodhousii*; HYCH = *Hyla chrysoscelis* - *Hyla versicolor* Complex; PSTR = *Pseudacris triseriata triseriata*; PSCR = *Pseudacris crucifer crucifer*; RABL = *Rana blairi*; RACA = *Rana catesbeiana*; RASP = *Rana sphenoccephala*; SCBO = *Spea bombifrons*.

<sup>2</sup> - Wetland T8 was sampled only in 1996; wetland TC replaced T8 as a sample site in 1997 and 1998.

<sup>3</sup> - Study site wetlands within each wetland type are listed in Appendix A.

<sup>4</sup> - *Ambystoma tigrinum tigrinum* were captured only in 1997 and only in wetland PTA at a relative abundance of 0.26 captures/100 trap days.

Appendix C. Larval amphibian relative abundance estimates(captures/trap day) by species and all species combined (total larvae) for each wetland in the Missouri River Post-flood Evaluation Project during 1996, 1997, and 1998.

[illegible]

[illegible]

[illegible]



Wetland -Year	Species														Total
	ACCR <sup>1</sup>	AMTE	BUAM	BUCO	BUWO	GAOL	HYCH	PSCR	PSTR	RABL	RACA	RACL	RASP	SCBO	Larvae
S13 - 1996 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S13 - 1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S13 - 1998 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S15 - 1996 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S15 - 1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S15 - 1998 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S19 - 1996 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S19 - 1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S19 - 1998	-	-	-	-	-	-	-	-	-	0.13	-	-	-	-	0.13
S21 - 1996 <sup>6</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S21 - 1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
S21 - 1998	-	-	-	-	0.38	-	-	-	-	-	-	-	-	-	0.38

<sup>1</sup>- ACCR = *Acris crepitans blanchardi*; AMTE = *Ambystoma texanum*; BUAM = *Bufo americanus americanus*; BUCO = *Bufo cognatus*; BUWO = *Bufo woodhousii woodhousii*; GAOL = *Gastrophryne olivacea*; HYCH = *Hyla chrysoscelis* - *Hyla versicolor* Complex; PSTR = *Pseudacris triseriata triseriata*; PSCR = *Pseudacris crucifer crucifer*; RABL = *Rana blairi*; RACA = *Rana catesbeiana*; RACL = *Rana clamitans melanota*; RASP = *Rana sphenoccephala*; SCBO = *Spea bombifrons*.

<sup>2</sup> - Wetland T8 was sampled only in 1996; wetland TC replaced T8 as a sample site in 1997 and 1998.

<sup>3</sup> - Study site wetlands within each wetland type are listed in Appendix A.

<sup>4</sup> - Total larvae relative abundance estimates included unidentified amphibian larvae.

<sup>5</sup> - Wetland was dry during larval sampling.

<sup>6</sup> - Wetland was flooded by Missouri River during larval sampling. Consequently, the wetland was not sampled.



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